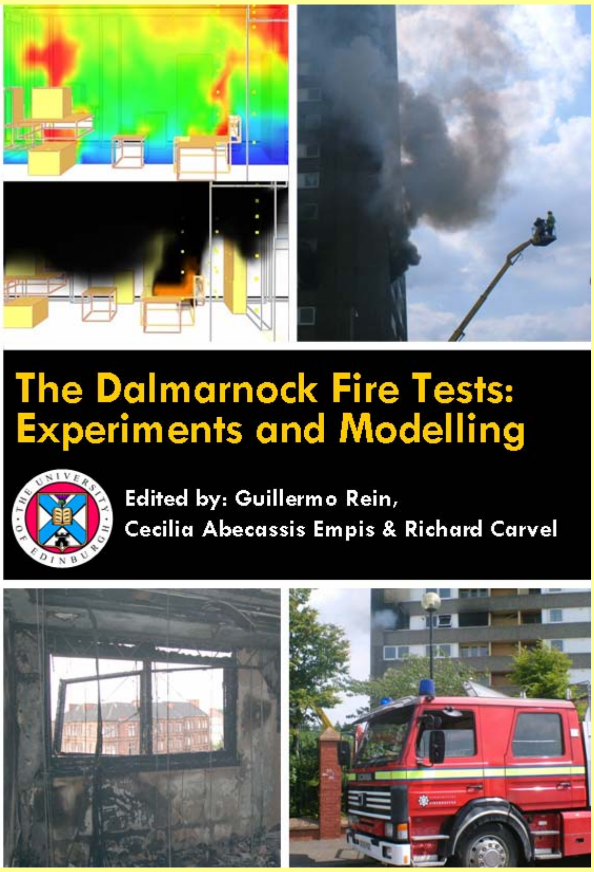
The Dalmarnock Fire Tests: Experiments and Modelling
Edited by G. Rein, C. Abecassis Empis and R. Carvel



Published by the School of Engineering and Electronics,
University of Edinburgh, 2007.
ISBN 978-0-9557497-0-4

5. Smoke Detection, CCTV and Remote Monitoring Systems

By Peter Massingberd-Mundy, Yun Jiang & Ming He

Introduction

This chapter presents an overview of the commercial equipment that was installed by Xtralis (formally Vision Fire & Security) to monitor and record data from the fire tests performed in Dalmarnock in July 2006 - as depicted in the BBC Horizon TV documentary "Skyscraper Fire Fighters". In addition to the two main apartment fires and some fire tests in the stair-well, Xtralis personnel performed some additional tests to illustrate the ignition phases of a fire which were not present in the other tests. Results from this test are presented along with an overview of the images and data remotely monitored and captured and during the two main apartment fires.

The paper illustrates the commercial state-of-the-art in remote monitoring and surveillance of fires and CCTV images – particularly focussing on the information obtained during critical initial phases, during which, targeted and informed intervention can be so successfully applied.

Introduction to Xtralis

Xtralis is the principle industrial partner in the FireGrid consortium and provides products and systems to protect life, critical assets and business continuity across the world. With a global network of companies and strong channels Xtralis is a global leader in very early warning smoke detection, fire protection system monitoring and control, voice alarm solutions, traffic detection and security surveillance systems. Most importantly, Xtralis is well positioned to bring the research findings of FireGrid closer to commercial reality.

Full details of the products currently offered by currently Xtralis can be found on their website (www.xtralis.com) but in summary they fall into the following product brands:

- ADPRO - Security surveillance systems
- ASIM - Traffic and intruder detection systems
- VESDA - Very Early Warning smoke detection
- MILLBANK - Voice alarm solutions and services
- PROACTIV - Fire control and management solutions

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
Copyright (c) School of Engineering and Electronics, University of Edinburgh, 2007. ISBN 978-0-9557497-0-4

Objectives for the Dalmarnock tests

The principle objectives of the Dalmarnock tests were set by Lion television and University of Edinburgh and are well covered elsewhere. For Xtralis the primary objective was to collect good data from commercial sensors (as opposed to sophisticated research sensors) and to ensure that more than just the lounge compartment was covered. A very important secondary objective was to demonstrate the capability of the commercial sensors and most importantly the remote monitoring packages that support them.

Xtralis equipment installed for the Dalmarnock tests

For the two main Dalmarnock apartment tests Xtralis installed:

- 12 VESDA detectors & 2 PROACTIV Fire Panels
- 50 PRECISION Smoke, Heat and CO detectors
- 12 ADPRO cameras
- 2 ADPRO Fastrace Video Surveillance Systems
- Remote Monitoring packages:
- Precision System Management (PSM)
- Video Central Gold (VCG)

Figures 1 and 2 show the essential layout of the detection equipment installed.

Each room in the flats had a VESDA aspirating smoke detector installed. These are able to accurately measure smoke obscuration levels in each room from 0.005 to 32 %obscuration/m. This is an enviable dynamic range and provides the earliest possible indication of an increase in obscuration while also monitoring it up to levels that would mean exit signs are barely visible from 2m.

Each room was also fitted with a standard optical point detector, with an alarm sensitivity of around 7 %obscuation/m (and capable of indicating up to about 20 %obscuration/m), an ionization detector, a heat detector and a CO detector.

Figure 3 shows a photo of the installed detectors – note the copper sampling pipe from the VESDA which was installed in the room above.

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
 ISBN 978-0-9557497-0-4

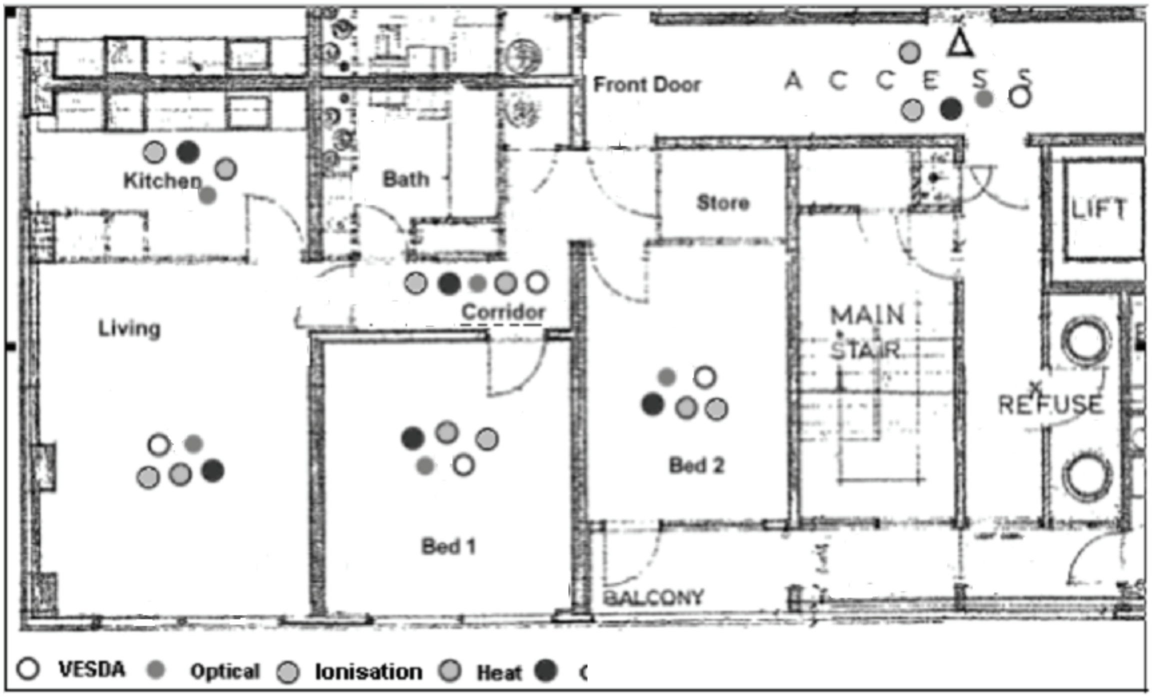


Figure 1 – Detection equipment installed in each room

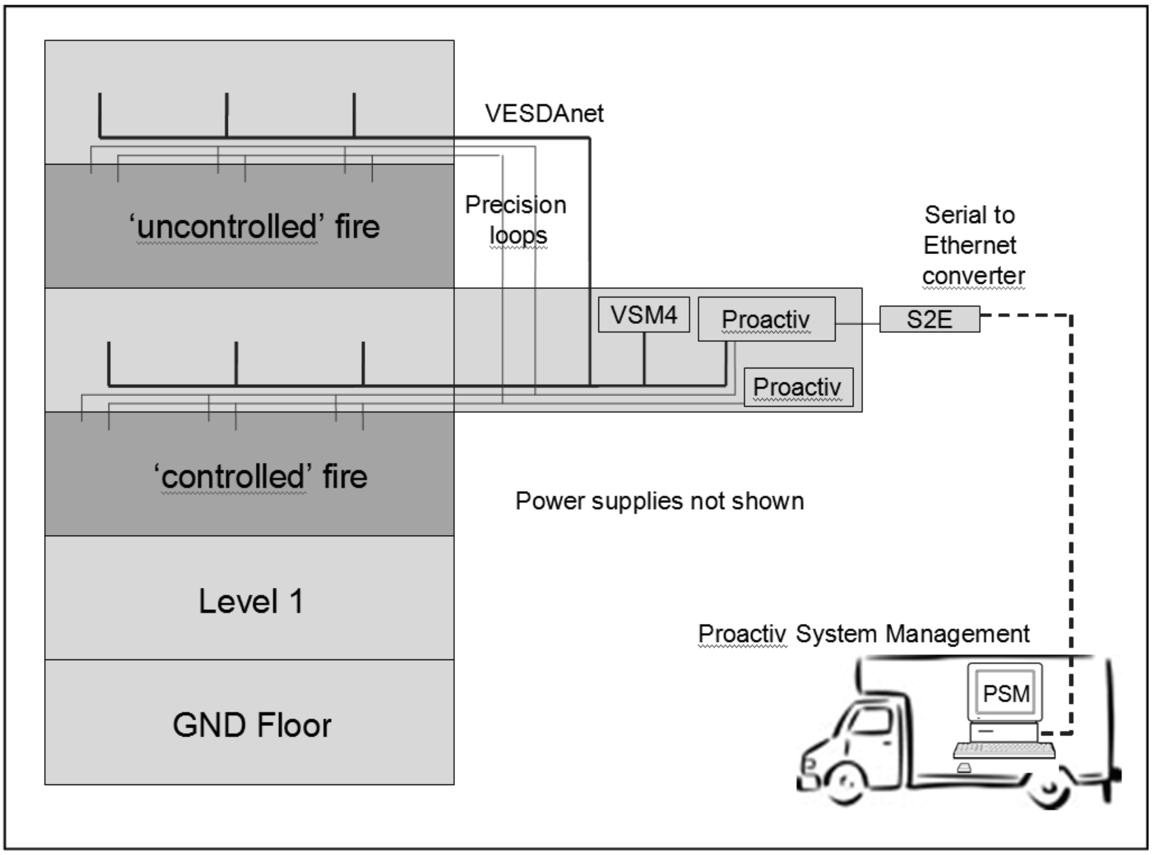


Figure 2 – Layout of Detection System across multiple floors

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
 ISBN 978-0-9557497-0-4

Figure 3 – The smoke detectors (with VESDA in room above)

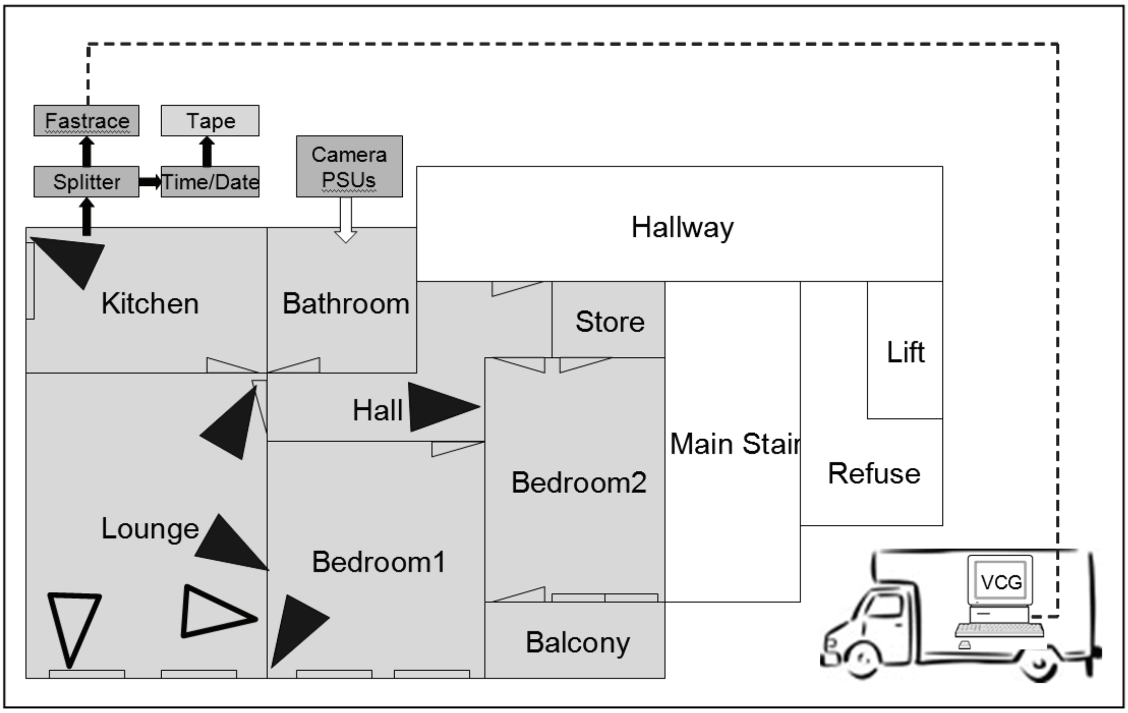


Figure 4 – Locations and arrangement of CCTV cameras

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.

Several CCTV cameras were installed in the main room and in adjacent rooms (i.e. the hall, kitchen and bedroom 1). For the 'uncontrolled' fire on level 4, four cameras were installed in the lounge whereas only two were installed for the 'controlled' fire on level 2. This is because the additional cameras (indicated in-off white in figure 4) were sponsored by Lion Television to provide additional footage for their Horizon documentary – such was the high quality of the images being recorded. In fact, the Producer/Director for Lion Television commented that he was impressed with the quality and longevity of the camera equipment installed and its instant review capabilities.

Each camera was installed in a protective housing with fire rated cabling used throughout. This arrangement proved extremely robust and some exceptional images of the fire were recorded. Most cameras were installed on the floor but even the ceiling mounted camera provided good images well into the fire despite the intense heat and smoke levels present.

Remote monitoring systems - CCTV

As indicated in Figure 5 the signals for individual cameras were passed through a video splitter so that separate feeds could be provided to the ADPRO FastTrace unit and to the Lion TV video recorders.

FastTrace is a market leading Video recorder and transmitter which, when connected to Video Central Gold (VCG - located in a van for Dalmarnock) provides many advanced features for monitoring, recording, trapping and reviewing events caught on CCTV. For the Dalmarnock experiments the alarm relays from the VESDA units were connected into the alarm inputs on the FastTrace unit and as such, stills from just before and at the very instance of alarm PLUS live streamed video of the current situation were displayed instantly on the VCG monitor.

In fact, what is not shown in Figure 4 is that we were are able to monitor the fire, as it was happening, through a broadband connection using a VCG system running in Melbourne, Australia because the FastTrace can manage concurrent connections with several VCG.

In a reality, the VCG is in operation in many Alarm Receiving Centres (ARCs) across the UK. These centres currently receive CCTV intruder events via the FastTrace triggers and are presented with still images and live footage of the incident to review and act on. Such centres typically receive fire alarm signals over separate dedicated systems such as Redcare but this is historic and increasingly the robust systems offered by ADPRO are being used to transmit fire events.

Remote monitoring systems – Fire Detection

With regard to the remote monitoring of the Fire detectors, a PC running the Proactiv Management System (PSM) was installed in the van at Dalmarnock (as indicated in Figure 2). This system was configured to show floor plans of each of the flats clearly indicating the location and status of each detector. As such the spread of smoke through the various rooms of the apartments was monitored live during the experiments. This

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
 ISBN 978-0-9557497-0-4

was invaluable, particularly during the 'controlled' fire, as this live information was used by Prof. José Torero to activate the various preventative measures planned to restrict the growth of the fire (e.g. closing windows and doors initially to prevent smoke spread but then opening them at a later stage to vent the smoke and increasing heat).

One particularly impressive aspect of the system was the text-to-speech feature which announced "Fire Alert on the VESDA LaserPLUS in the level 4 lounge" just 9 seconds after the fire was ignited.

The PSM system also provided the facility to display and record the readings from each individual detector.

In a live installation, the floor plans on PSM are configured in a hierarchy and operators can click down to the status of individual detectors. Most importantly the display for each device includes a cached record of the previous 10 minutes so that operators can immediately access the dynamics of the situation – specifically the speed and direction of change. There is nothing to beat a simple graph! In fact, the one of the biggest challenges for FireGrid is how to present a wealth of data from numerous detectors including historic readings, live readings *and* future predictions in a manner that is intuitive and truly informative to a fire fighter in the front line of an incident.

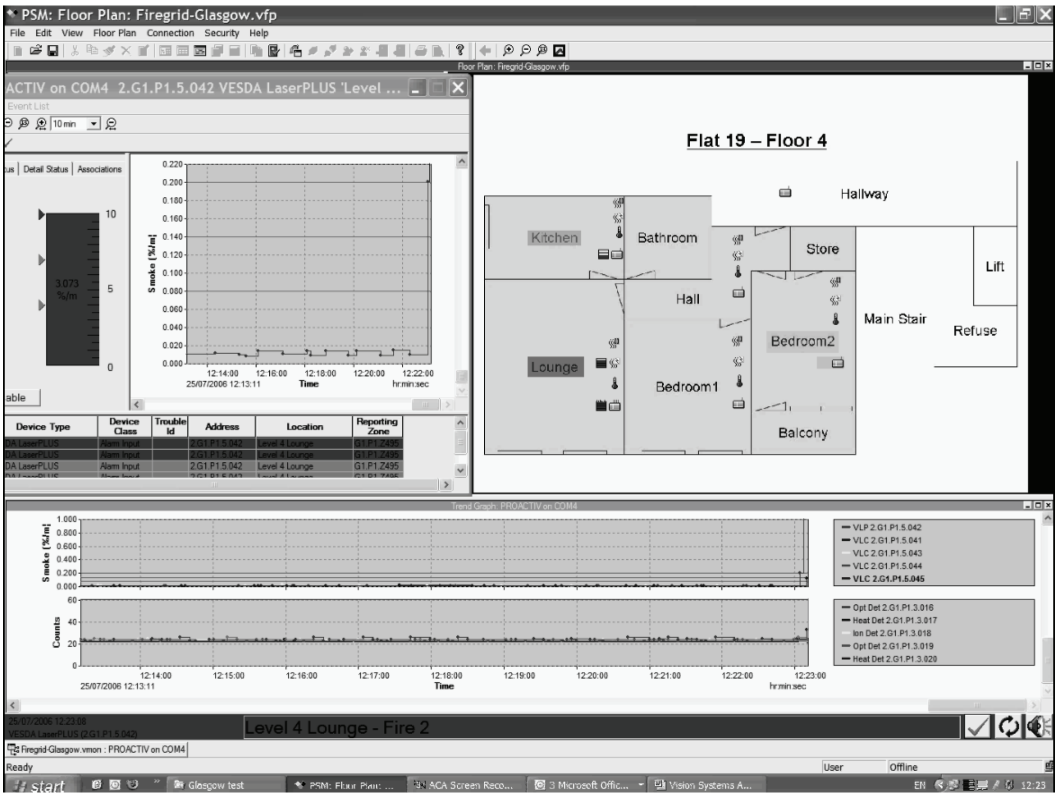


Figure 5 – Proactive System Management (live at 19 seconds into the 'uncontrolled' fire)

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
Copyright (c) School of Engineering and Electronics, University of Edinburgh, 2007. ISBN 978-0-9557497-0-4

Results and discussion

The majority of the results provided by Xralis are dynamic and best presented on Video. For example, the information presented by PSM was recorded using ACA Screen recorder. After ignition it was observed that the Lounge VESDA detected in 9 seconds, the Kitchen VESDA 9 seconds later shortly followed by the Ionisation detector in the lounge. A still record of this moment is shown in Figure 5.

Bearing in mind the transport time of 5 seconds on the VESDA detector (this being the time taken to transport the samples from the sampling point to the detector) it is clear that the VESDA effectively detected the fire at about 4 seconds after ignition. This is no surprise as the fire was set in a waste paper bin with some accelerant so a flaming fire was produced instantly. This can be clearly seen on the screenshot taken from the VCG only 4 seconds after ignition and shown in Figure 6.

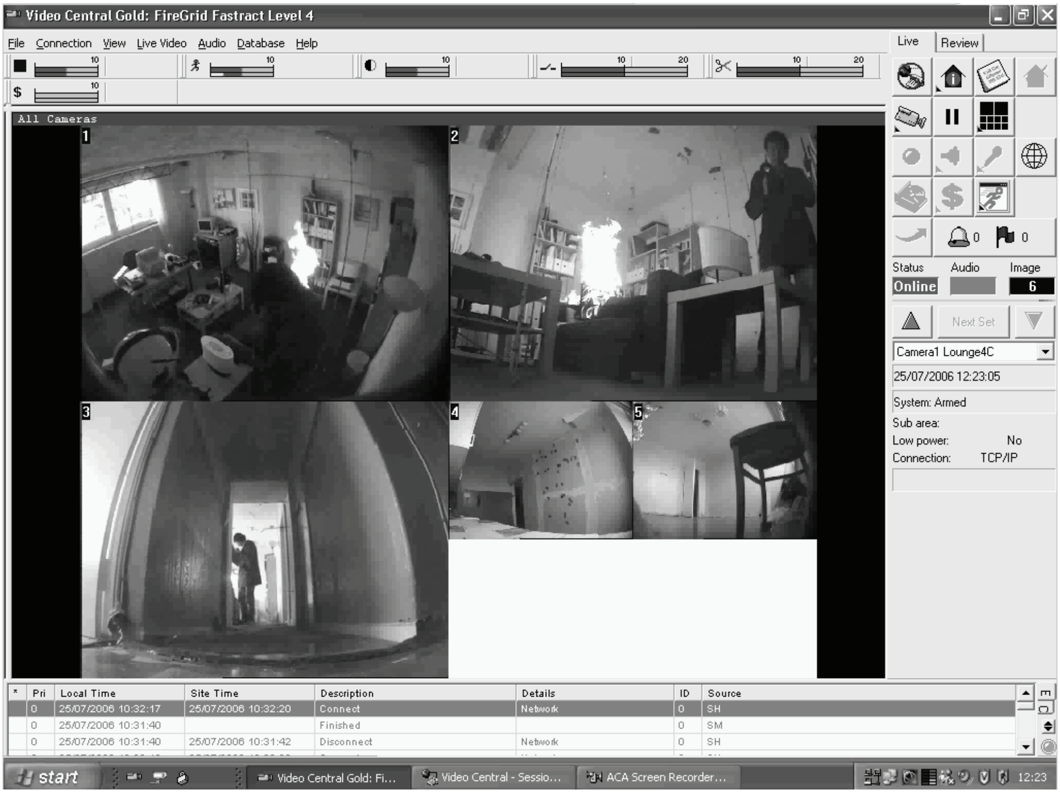


Figure 6 – Video Central Gold (live at 4 seconds into the 'uncontrolled' fire)

Some of the most exciting images on VCG were when the fire spread up the bookcase and ignited a paint canister on the shelves. This moment is shown in the upper screenshot in Figure 7. This was clearly more dramatic than the still can convey but this still also shows how the time and images of the initial event are presented – as highlighted in blue showing the QUAD alarm registered at 12:23:11. Within a couple of mouse clicks the operator can view the images recorded at that particular moment (Figure 8). It does not take much imagination to understand how useful this instantly recorded and tagged video

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
 ISBN 978-0-9557497-0-4

would be to fire fighters travelling to or arriving at the scene. Particularly as the most likely camera in a real installation would be camera No.1

Figure 7 – Video Central Gold (at the moment when the paint canister ignited)

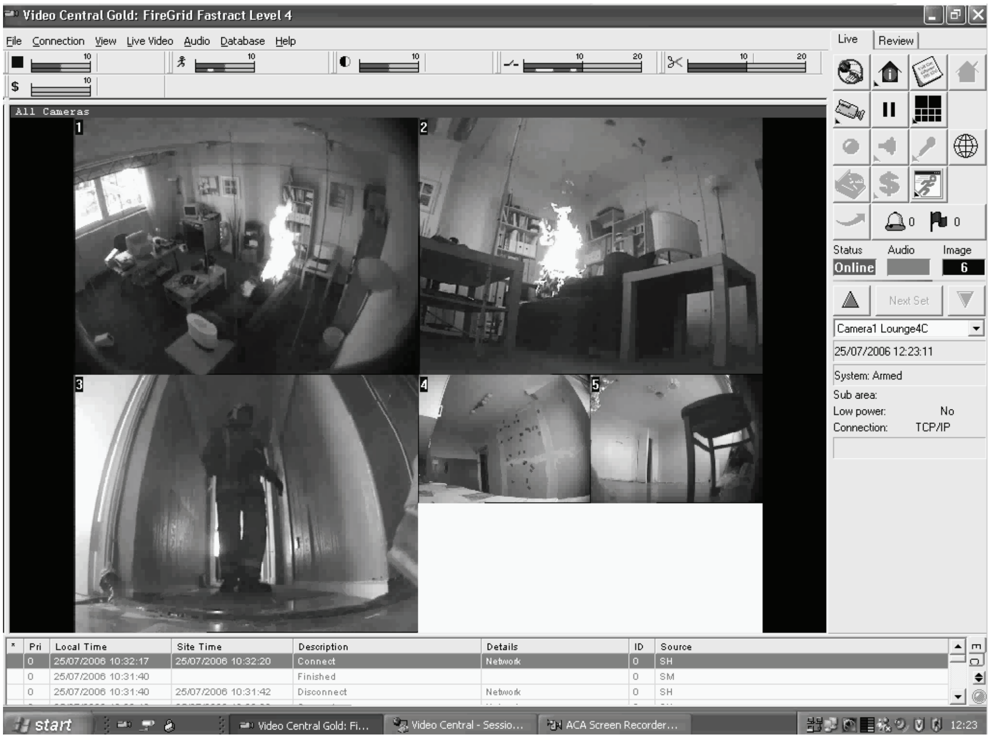


Figure 8 – Video Central Gold (historical view of the fire at the moment of Alarm)

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
Copyright (c) School of Engineering and Electronics, University of Edinburgh, 2007. ISBN 978-0-9557497-0-4

Figure 9 – Flat 19 after the 'uncontrolled' fire

Figure 10 – Flat 7 after the 'controlled' fire

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
 ISBN 978-0-9557497-0-4

The final outcome of the 'uncontrolled' fire was devastation (see Figure 9) – whereas, as a result of early intervention, the damage sustained during the 'controlled' fire was significantly less (see Figure 10). This is perhaps a little misleading as the fire fighters intervened in the 'controlled' fire much later. However, by directly comparing the fires 90 seconds after ignition it is clear that the rate of spread and growth in the 'controlled' fire was significantly less. This is illustrated in Figure 11 where the images to the left of the red line show the 'controlled' fire at 90 seconds whereas those on the right show the 'uncontrolled' fire. The PSM images clear show that the smoke has spread to only 2 rooms in the 'controlled' fire and the images from VCG confirm that the fire growth is significantly slower in the 'controlled' fire.

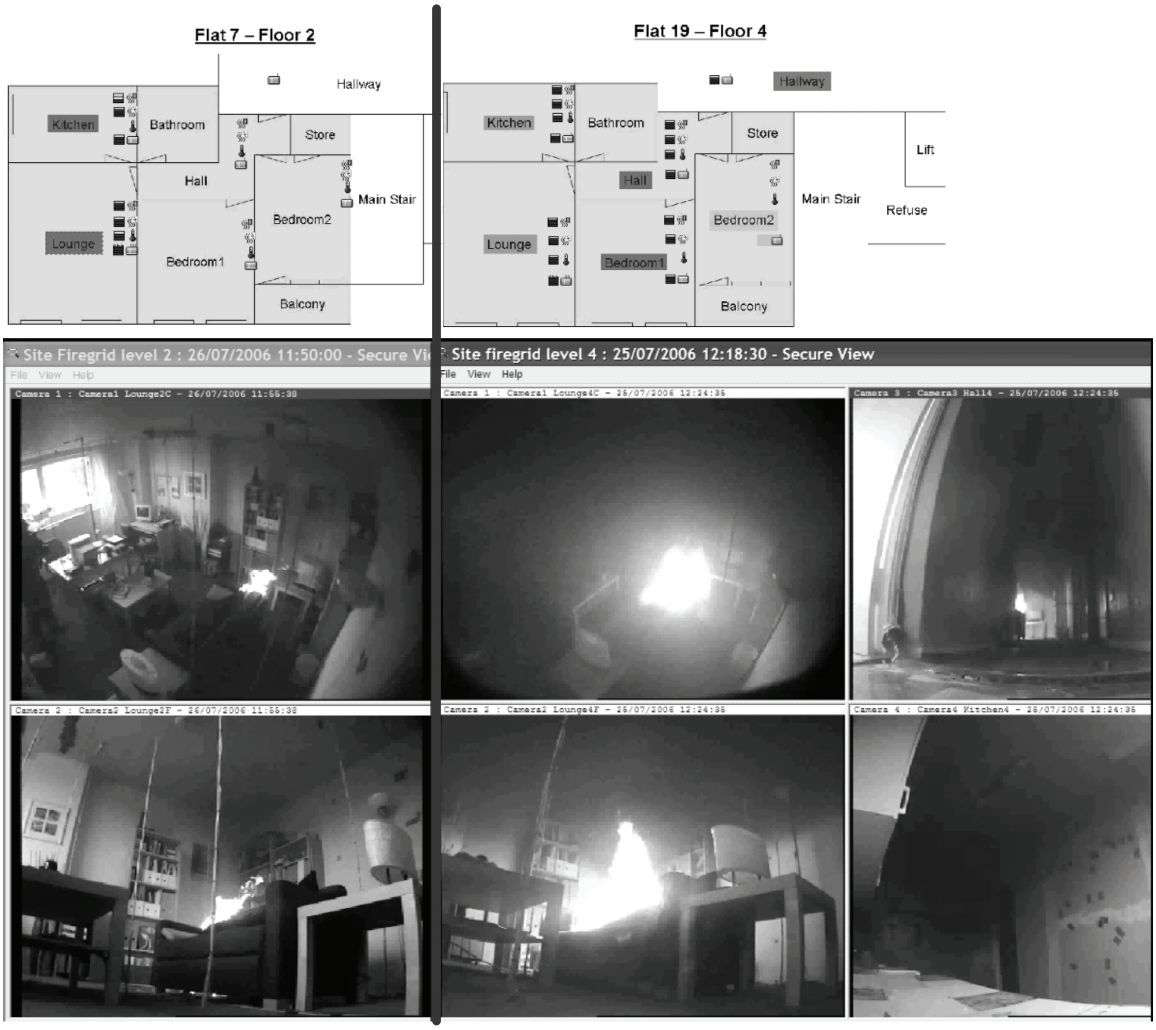


Figure 11 – Summary of fires 90 seconds after ignition.

Post fire analysis

While the Xtralis images and information were valuable for monitoring the live status of the fire during the experiments the logged results have had immense value. The synchronised timings have enabled confirmation of events such as when the door opened, and when the window broke. Moreover the CCTV images were used extensively in the Horizon documentary and the images from PSM and VCG were used to illustrate the data being presented and acted on by Professor Torero in a re-enactment of the control rooms.

Of more scientific interest has been the comparison between the measured results and those predicted using fire models. Over and above the round robin initiative organised by the University of Edinburgh, Xtralis have used the Computational Fluid Dynamics code FDS (Fire Dynamics Simulator) to predict the likely response time of the detectors used – this being our principle research focus.

Two sets of simulations have been carried out by Xtralis using various fire source profiles in FDS. The first set used a Heat Release Rate (HRR) profile from the NIST sofa test while the second set used the HRR profile obtained from the round robin simulation (see chapter 10) without altering any other parameters in FDS settings. The essential objective of the simulations was to predict the response time of the various detectors installed in the experiments. Figure 12 shows the two different HRR profiles while Figure 13 shows a graphs summarising the predicted times compared to the times actually observed.

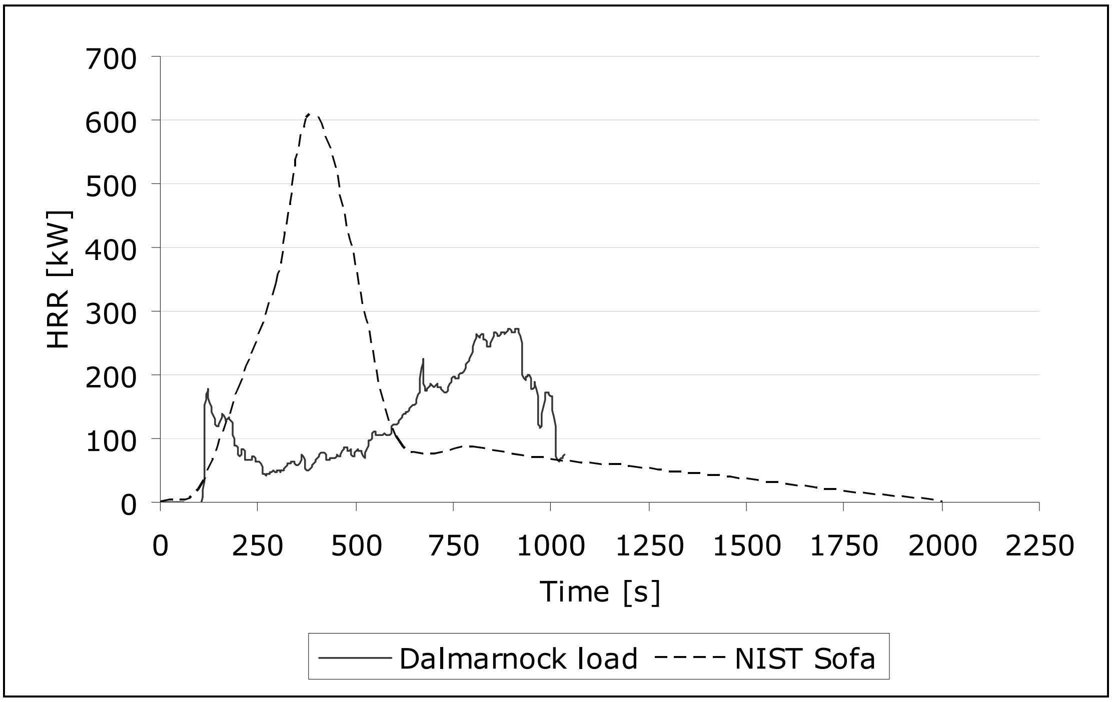


Figure 12 – Two Heat Release Rate (HRR) profiles used in FDS simulations

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.
 ISBN 978-0-9557497-0-4

Different fire source profiles have different effects on predictions of the VESDA (Aspirating Smoke Detector) response and ionisation and optical (Point Detector) response. The reason is that ASD, with high sensitivity, responses to very small size of fire at incipient fire stage. Conversely, while point detectors can detect relatively large fires their detection performance is also affected by environmental conditions surrounding the detector heads, such as temperature rise and gas velocity. Therefore, it's hard to predict response time of point detectors accurately without accurate modelling of fire development, including flame spread over non-adjacent objects.

Conversely, prediction of ASD detection has higher accuracy under both fire source configurations, except in the rooms far away from the room of fire origin.

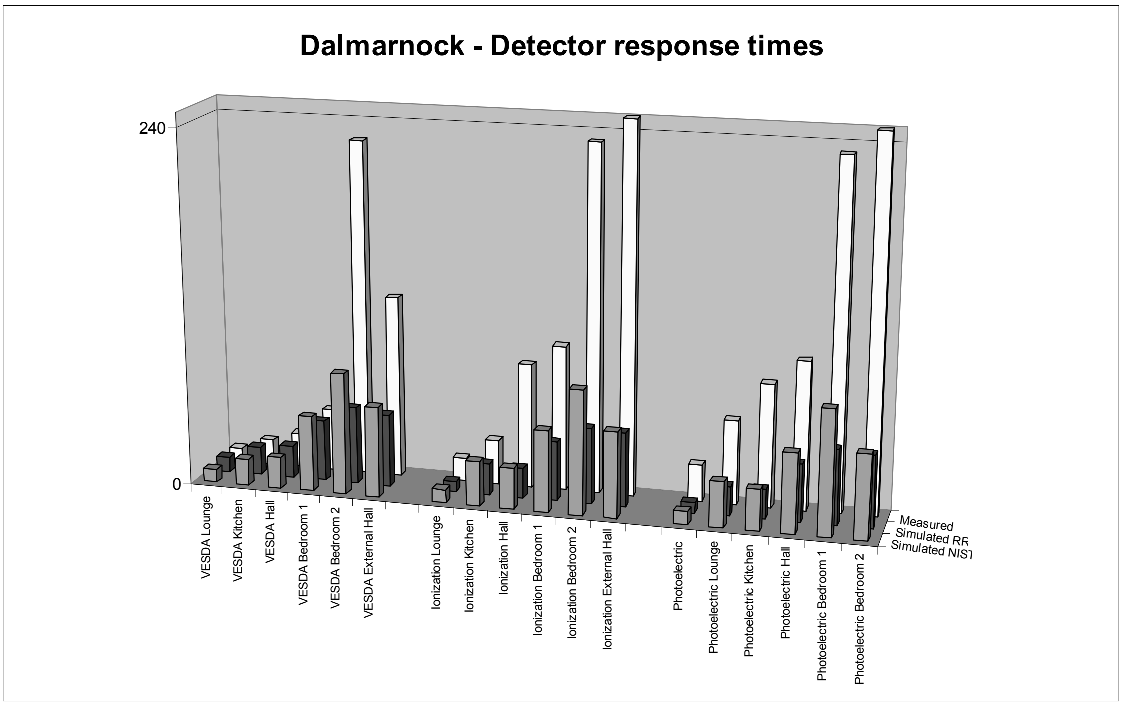


Figure 13 – Summary of predicted detector response times compared to actual

Ignition phase demonstration

In addition to the two main fires at Dalmarnock, Xtralis personnel instrumented the fire tests conducted in the stair well and also conducted some additional test to illustrate the ignition phases of a more likely fire scenario.

It is clear from Figure 6 that the ignition of the fires test was aggressive and led to an instantaneous flaming fire. In many situations this is not the case and the ignition phase is more prolonged. It is important to appreciate this when considering the experiments as the clear objective of the two main experiments was to observe and model the fire growth phases. Little research has been conducted on the ignition (or incipient) phase of a fire but Xtralis are actively involved in this area as it is very relevant to the correct application of the VESDA early warning smoke detection system.

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.

For the ignition tests at Dalmarnock, a towel was draped into an electric toaster. There was no fluid accelerant or butane burner - the ignition phase was more realistic. Figure 14 shows a still of the arrangement at the point when visible smoke was observed. This photo was taken shortly after the VESDA detector had indicated an alarm but before the optical point detector had activated.

Figure 14 – More realistic ignition phase

The demonstration was not intended to show a "slow" ignition but rather a more realistic ignition phase with flaming occurring within 2 minutes as opposed to occurring instantaneously. Clearly there are many scenarios where the ignition phase is much longer than 2 minutes – perhaps several hours. A fire during this stage is often referred to an "incipient fire" - where a real fire may or may not develop. Unfortunately, the ambiguity of such an incipient fire makes it unsuitable for a demonstration whereas a 2 minute ignition phase is sufficient to illustrate the benefits of early warning.

Figure 15 shows a still record from the latter stages of the test – just before power was removed from the toaster. The arrows on the timeline along the bottom correspond to:

1. Test start at 19:42:50
2. VESDA Alert at 19:43:24 (34 seconds)
3. VESDA Fire at 19:43:32 (42 seconds)
4. Optical Alarm at 19:44:08 (1min 12 seconds)
5. First flames at 19:44:24 (1min 34 seconds)
6. Power off at 19:44:31 (1min 41 seconds)

The Dalmarnock Fire Tests: Experiments and Modelling. Edited by G. Rein, C. Abecassis Empis and R. Carvel.

Figure 15 – FastTrace timeline of the ignition demonstration

It is clear that the VESDA system provided a minutes warning before flaming occurred compared with just over 20 seconds warning from the optical point detector. 40 seconds additional time to intervene in a scenario that produced flames in just over 1½ minutes is very significant.

Conclusions

Xtralis systems installed for the tests in Dalmarnock provided reliable and instant feedback on the progress of the fire during the experiments.

As the only instrumentation installed in several rooms the information recorded has been invaluable to understanding and analysis the spread of the fires through the apartments.

The quality and longevity of the images provided by ADPRO mean that they were used extensively in the Horizon documentary and the ability instantly recall images from events has proved valuable in reconstructing and analysing the experiments.

Post fire analysis of the results show that predictions of the detector response time are more accurate for VESDA detectors than for point detectors due to the complexities of smoke entry characteristics of the latter.

A demonstration of the ignition phases of a fire using a towel draped over a toaster show that when flaming occurs within 1½ minutes, the advantages of early warning smoke detection are significant and can provide vital seconds to prevent a fire transferring from an ignition phase to a growth phase and ultimately to a destruction phase.

When citing chapters from this volume, the following reference style should be used:

Authors, Chapter no., Title, The Dalmarnock Fire Tests: Experiments and Modelling, Edited by G. Rein, C. Abecassis Empis and R. Carvel, Published by the School of Engineering and Electronics, University of Edinburgh, 2007. ISBN 978-0-9557497-0-4

The contents of this book and much of the other published output from the BRE Centre for Fire Safety Engineering can be downloaded from the Edinburgh Research Archive:

http://www.era.lib.ed.ac.uk/handle/1842/1152

Produced as part of the FIRESEAT symposium series:

http://www.see.ed.ac.uk/FIRESEAT/

Published by the

SCHOOL *of* ENGINEERING *and* ELECTRONICS
UNIVERSITY *of* EDINBURGH
KING'S BUILDINGS, MAYFIELD ROAD
EDINBURGH, EH9 3JL, UNITED KINGDOM
Tel: +44 (0) 131 650 1000
Fax: +44 (0) 131 650 6554
fire.research@ed.ac.uk
http://www.see.ed.ac.uk/fire/

November 2007